AD-A068 929 WISCONSIN UNIV-MADISON MATHEMATICS RESEARCH CENTER F/G 9/2
NONSTANDARD ARITHMETIC PACKAGES FOR FORTRAN.(U)
JAN 79 J M YOHE DAAG29-75-C-0024
UNCLASSIFIED MRC-TSR-1907 NL

| OF |
AD
A068929

END
DATE
FILMED
6-79
DDC

LEVEL II

AD A068929

DDC FILE COPY

MRC Technical Summary Report #1907

NONSTANDARD ARITHMETIC PACKAGES FOR FORTRAN

J. M. Yohe

Mathematics Research Center
University of Wisconsin—Madison
610 Walnut Street
Madison, Wisconsin 53706

DDC RECEIVED MAY 24 1979 C

January 1979

Received November 22, 1978

Approved for public release
Distribution unlimited

Sponsored by

U. S. Army Research Office
P.O. Box 12211
Research Triangle Park
North Carolina 27709

79 05 07 149

UNIVERSITY OF WISCONSIN - MADISON
MATHEMATICS RESEARCH CENTER

(6) NONSTANDARD ARITHMETIC PACKAGES FOR FORTRAN .

(10) J. M./ Yohe (1)

(9) Technical Summary Report #1907
(11) January 1979

ABSTRACT

We describe various available supporting packages for the AUGMENT precompiler for FORTRAN, and provide instructions for their use in conjunction with AUGMENT.

AMS(MOS) Subject Classification: 68A10

Key words: FORTRAN Precompiler
Nonstandard Data Types
Software Packages
Multiple Precision Arithmetic
Interval Arithmetic
Triplex Arithmetic
Analytic Differentiation

Work Unit Number 8 (Computer Science)

(12) 27p.

(14) MRC-TSR-1907

ACCESSION for
NTIS White Section
DDC Buff Section
UNANNOUNCED
JUSTIFICATION
BY
DISTRIBUTION/AVAILABILITY CODES
SPECIAL
A

(1) Academic Computing Services
The University of Wisconsin - Eau Claire
Eau Claire, Wisconsin 54701

(5) Sponsored by the U. S. Army under Contract No. DAAG29-75-C-0024 and by the Universities of Freiburg i. Br. and Karlsruhe, West Germany.

221 200

SIGNIFICANCE AND EXPLANATION

Certain computational problems require the use of special arithmetics in their solution; examples include multiple precision arithmetic, interval arithmetic, and others. Unfortunatly FORTRAN (like most computer languages) does not allow one to use nonstandard data types gracefully.

The AUGMENT precompiler for FORTRAN (which was developed at MRC) is a program which greatly simplifies the use of nonstandard data types in FORTRAN by enabling the user to write programs as though the nonstandard type were standard. AUGMENT does not have these nonstandard types "built in", but instead presumes the existence of the supporting package(s) and syntactic descriptions thereof.

Several nonstandard arithmetic packages designed for use with AUGMENT are now available; these include interval arithmetic, multiple precision arithmetic, triplex arithmetic, both single and multiple precision, and analytic differentiation of FORTRAN statements.

The purpose of this guide is to describe the use of AUGMENT and to list all of the generally available supporting packages for the AUGMENT precompiler that we are aware of at this writing.

The responsibility for the wording and views expressed in this descriptive summary lies with MRC, and not with the author of this report.

NONSTANDARD ARITHMETIC PACKAGES FOR FORTRAN

J. M. YOHE (1)

1. Introduction:

Certain computational problems require the use of special arithmetics in their solution; examples include multiple precision arithmetic, interval arithmetic, and others. Unfortunately, FORTRAN (like most languages) does not allow one to use nonstandard data types gracefully.

The Mathematics Research Center, University of Wisconsin - Madison, Madison, Wisconsin, has developed a precompiler for FORTRAN, called AUGMENT [1], [2], which enables one to write programs employing nonstandard arithmetics using standard FORTRAN syntax. Several nonstandard arithmetic packages designed for use with AUGMENT are also available; these include interval arithmetic, multiple precision arithmetic, triplex arithmetic, both single and multiple precision, and analytic differentiation of FORTRAN statements.

The purpose of this guide is to describe the use of AUGMENT and these nonstandard arithmetic packages. Of course, the documentation for the appropriate components of the library should be consulted for further details.

We have attempted to list here all of the generally available supporting packages for the AUGMENT precompiler that we are aware of at this writing. Other applications of AUGMENT have been developed, and some of these are listed in [3]; however, the corresponding supporting packages are not known to us to be available. Undoubtedly, other packages will become available in the future. We plan to update this document as more available packages are brought to our attention.

(1) Academic Computing Services
The University of Wisconsin - Eau Claire
Eau Claire, Wisconsin 54701

Sponsored by the U. S. Army under Contract No. DAAG29-75-C-0024, and by the Universities of Freiburg i. Br. and Karlsruhe, West Germany.

2. Writing a program for a nonstandard data type with the aid of AUGMENT:

Nonstandard data types should be declared in your program in the same manner as standard data types. The form of the declaration is

<typename><list>,

where <typename> is the name of the nonstandard data type, and <list> is the same as for standard data types. In particular, variables may be dimensioned in the type declaration statements. Note that more than one nonstandard data type may be used in a given program.

The syntax of a given nonstandard data type is usually obvious, but in any case is fully described in the documentation for the particular data type in question. Mixed-mode expressions may be permissible (the documentation will tell you if they are) and, if so, are written in exactly the same fashion as mixed-mode expressions involving standard data types.

Conversions between standard and nonstandard types may be invoked implicitly [via the replacement (=) operator or mixed-mode expressions] or explicitly [via naming the appropriate conversion operation or function]. The documentation again should provide the necessary details.

Input/output must be done via calls to the appropriate nonstandard routines, unless the standard FORTRAN I/O is adequate (it usually is not). Consult the documentation for details.

Certain FORTRAN statements are not processed by AUGMENT, and therefore must be used with care. Usually, this means that the user must know a great deal about the nonstandard data type package in order to use these statements properly when a nonstandard variable is involved. Statements not processed by AUGMENT are

DATA
EQUIVALENCE
All I/O statements

Further details on AUGMENT may be found in [1] and [2].

3. Compiling and executing your program - general form of runstream:

The general form of the runstream is independent of the data type or types used. We give an outline here; in later sections we give necessary modifications.

```
1. [ATTACH APPROPRIATE FILES TO OBTAIN AUGMENT AND
       THE DESIRED NONSTANDARD PACKAGES]
2. [INVOKE AUGMENT]
   PRINT SUPPRESS (if listing of the description decks
                   is not desired)
3. [SUPPLY APPROPRIATE DESCRIPTION DECKS TO AUGMENT]
   *BEGIN
   <any special cards>
   *DISABLE WARNINGS (if AUGMENT warning messages
                                 are not desired)
4. [SOURCE CODE TO BE PROCESSED BY AUGMENT]
   *END
5. [COMPILE PREPROCESSED PROGRAM, WHICH HAS BEEN WRITTEN
      ON LOGICAL UNIT 20]
6. <any other processing, such as preparation of files, compi-
    lation of other modules, etc.>
7. [INVOKE LINKAGE EDITOR]
   <special instructions to linkage editor, aside from
     the rather obvious requirement that the nonstandard
     package must be loaded with the program>
8. [EXECUTE PROGRAM]
   <data>
9. [END OF JOB]
```

If more than one nonstandard data type is to be used in a given program, all appropriate DESCRIPTIONs must be supplied, all required special cards must be included in the designated places, and all relevant supporting package modules must be loaded with the program.

In the appendix, we provide the detailed runstream and modifications necessary for each nonstandard package (see Section 4) for the University of Wisconsin - Madison's UNIVAC 1110. It is suggested that a similar guide be prepared at each installation offering AUGMENT to its users.

4. Details of specific nonstandard packages:

In this section, we provide general information on available nonstandard packages. Specific information for the University of Wisconsin's UNIVAC 1110 is given in the appendix; it is suggested that similar information be provided at each installation having AUGMENT.

A-1) DOUBLE PRECISION COMPLEX ARITHMETIC

<typename> := DBLCOMPLEX

Synopsis:

A complete library for performing complex calculations in double precision.

Documentation:

F. D. Crary, The AUGMENT precompiler I: user information, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report #1469, September, 1974 (revised April, 1976), Appendix B.

Availability:

Available from:

Mathematics Research Center
University of Wisconsin - Madison
610 Walnut St.
Madison, Wisconsin 53706

Available for:

UNIVAC 1100
[can be used on any ANSI FORTRAN-equipped computer with minor modifications]

Languages:

UNIVAC 1100 FORTRAN-V

Other packages used: None

Special cards to be added after *BEGIN: None

Special instructions to the linkage editor: None

Other comments:

DATA statements peculiar to UNIVAC 1100 FORTRAN-V are used in three routines. In addition, the package uses a trace routine which must be supplied by the user (either in operational or dummy form). See documentation.

A-2) MULTIPLE PRECISION ARITHMETIC (BRENT)

<typename> := MULTIPLE

Synopsis:

Variable precision, variable base multiple precision arithmetic, together with an extensive library of elementary and special functions.

Documentation:

Richard P. Brent, Judith A. Hooper, and J. M. Yohe, An AUGMENT interface for Brent's multiple precision arithmetic package, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report # 1868, August, 1978.

Richard P. Brent, MP Users guide, Australian National University, Canberra, Australia, Computer Centre, Technical Report # 54, September, 1976 (Revised July, 1978).

Richard P. Brent, A FORTRAN multiple-precision arithmetic package, Assoc. Comput. Mach. Trans. Math. Software 4 (1978), 57-70.

Availability:

Available from:

Computer Centre
Australian National University
Canberra, Australia

Available for:

Any computer with at least 16 bits per word and
ANSI standard FORTRAN

Languages:

ANSI Standard FORTRAN

Special cards to be added after *BEGIN: None

Special instructions to the linkage editor: None

Other comments:

Program must include a call to a special initialization subroutine prior to using multiple precision arithmetic. See documentation.

A-3) MULTIPLE PRECISION ARITHMETIC (WYATT, LOZIER, AND ORSER)

<typename> := SUPER PRECISION
SUPER COMPLEX

Synopsis:

Arbitrary precision floating point real and complex arithmetic, together with an extensive library of elementary functions.

Documentation:

W. T. Wyatt, Jr., D. W. Lozier, and D. J. Orser, A portable extended precision arithmetic and library with FORTRAN precompiler, Assoc. Comput. Mach. Trans. Math. Software 2 (1973), 209-231.

Availability:

Available from:

Computing Services
352 General Services Building
The University of Alberta
Edmonton, Canada T6G 2H1

Available for:

Any computer with ANSI stadard FORTRAN

Languages:

ANSI Standard FORTRAN

Other packages used: None

Special cards to be added after *BEGIN: None

Special instructions to the linkage editor: None

Other comments:

The multiple precision package of Brent is, according to Lozier, superior to this package. However, Brent's package does not include a complex arithmetic capability.

The AUGMENT interface for this package was developed at the University of Alberta.

A-4) MULTIPLE PRECISION ARITHMETIC

<typename> := MULTIPLE

Synopsis:

This package provides multiple precision arithmetic operations, with directed roundings, for the UNIVAC 1110. Some elementary functions are also provided.

Documentation:

F. D. Crary, Multiple precision arithmetic package - revised FORTRAN interface, University of Wisconsin - Madison, Mathematics Research Center, internal memorandum.

F. D. Crary, Multiple precision arithmetic design with an implementation on the UNIVAC 1108, University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report # 1123, May, 1971.

Availability:

Available from:

Mathematics Research Center
University of Wisconsin - Madison
610 Walnut St.
Madison, Wisconsin 53706

Available for:

UNIVAC 1100

Special cards to be added after *BEGIN: None

Special instructions to the linkage editor: None

Other comments:

The precision of this package is currently 97 bits. For instructions on changing the precision, see documentation.

This package includes only arithmetic operations and a few elementary functions. For a more comprehensive package, see the package of Brent.

B-1) INTERVAL ARITHMETIC (SINGLE PRECISION)

<typename> := INTERVAL

Synopsis:

This package provides a complete collection of subprograms for carrying out calculations in interval arithmetic. The package includes all normally-implemented special functions, a wide range of functions peculiar to interval arithmetic, and complete error checking.

Documentation:

J. M. Yohe, The INTERVAL arithmetic package, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report # 1755, June, 1977.

Availability:

Available from:

Mathematics Research Center
University of Wisconsin - Madison
610 Walnut St.
Madison, Wisconsin 53706

Available for:

UNIVAC 1100
IBM System/360-370
CDC Cyber
DEC-10
PDP-11
Honeywell 600/6000

Languages:

Extended ANSI Standard FORTRAN
Assembly language

Special cards to be added after *BEGIN:

*CONVERT EXTENDED - DOUBLE PRECISION

Special instructions to the linkage editor:

BPACOM and INTCCOM must be loaded with the program

Other comments: None

B-2) INTERVAL ARITHMETIC (MULTIPLE PRECISION)

<typename> := INTERVAL

Synopsis:

This is a portable, multiple precision version of the package described in B-1 above, and includes all features of that package. In its present form, the precision is approximately 28 decimal digits, although it is not difficult to increase the precision even further.

Documentation:

J. M. Yohe, Multiple precision interval arithmetic, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report (to appear, 1979).

Availability:

Available from:

Mathematics Research Center
University of Wisconsin - Madison
610 Walnut St.
Madison, Wisconsin 53706

Available for:

Any computer with ANSI standard FORTRAN

Languages:

Extended ANSI Standard FORTRAN

Other packages used:

Brent's Multiple Precision Arithmetic Package

Special cards to be added after *BEGIN:

*CONVERT EXTENDED - MULTIPLE

Special instructions to the linkage editor:

BPACOM and INTCCOM must be loaded with the program

Other comments: None

B-3) TRIPLEX ARITHMETIC (SINGLE PRECISION)

<typename> := TRIPLEX

Synopsis:

Triplex arithmetic is like interval arithmetic, except that in addition to the endpoints a main (or "most probable") value is also carried. This package is based on the interval arithmetic package described in (B-1). It contains routines for evaluating the standard arithmetic operations and functions, plus operators and functions peculiar to triplex arithmetic.

Documentation:

Klaus Boehmer and J. M. Yohe, Triplex arithmetic for FORTRAN, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report (to appear, 1978).

Availability:

Available from:

Mathematics Research Center
University of Wisconsin - Madison
610 Walnut St.
Madison, Wisconsin 53706

Available for:

UNIVAC 1100
[Versions for other computers listed under (B-1) can be produced with little difficulty.]

Languages:

Extended ANSI Standard FORTRAN
Assembly language

Other packages used:

BPA package supporting single precision interval arithmetic

Special cards to be added after *BEGIN:

*CONVERT EXTENDED - DOUBLE PRECISION

Special instructions to the linkage editor:

BPACOM and TPXCCOM must be loaded with the program

Other comments: None

B-4) TRIPLEX ARITHMETIC (MULTIPLE PRECISION)

<typename> := TRIPLEX

Synopsis:

This package is a complete, portable multiple precision triplex arithmetic package based on the multiple precision arithmetic package of Brent (see A-2). In its present form, the arithmetic carries approximately 28 significant digits, although it is not difficult to increase the precision even further. The package includes all arithmetic operations and standard FORTRAN functions, plus many functions and operators peculiar to triplex arithmetic.

Documentation:

Klaus Boehmer and J. M. Yohe, Triplex arithmetic for FORTRAN, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report (to appear, 1978).

Availability:

Available from:

Mathematics Research Center
University of Wisconsin - Madison
610 Walnut St.
Madison, Wisconsin 53706

Available for:

Any computer with ANSI standard FORTRAN

Languages:

Extended ANSI Standard FORTRAN

Other packages used:

BPA package supporting multiple precision interval arithmetic
Brent's Multiple Precision Arithmetic Package

Special cards to be added after *BEGIN:

*CONVERT EXTENDED - MULTIPLE

Special instructions to the linkage editor:

BPACOM and TPXCCOM must be loaded with the program

Other comments: None

C-1) ANALYTIC DIFFERENTIATION - TAYLOR SERIES EXPANSION

<typename> := TAYLOR

Synopsis:

Automatic Taylor series expansion of FORTRAN functions.

Documentation:

G. Kedem, Automatic differentiation of computer programs, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report # 1697, November, 1976.

Availability:

Available from:

Mathematics Research Center
University of Wisconsin - Madison
610 Walnut St.
Madison, Wisconsin 53706

Available for:

Any computer with ANSI standard FORTRAN

Languages:

ANSI Standard FORTRAN

Special instructions for description deck:

The description deck is in two logical parts: a heading and a body. The user must supply an intervening card, containing the number of derivatives desired as an integer beginning in Column 2.

Special cards to be added after *BEGIN: None

Special instructions to the linkage editor: None

Other comments:

User must provide work space and write subroutine to compute function in question. See documentation.

C-2) ANALYTIC DIFFERENTIATION - GRADIENT COMPUTATION

<typename> := GRADIENT

Synopsis:

Automatic gradient computation of FORTRAN functions.

Documentation:

G. Kedem, Automatic differentiation of computer programs, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report # 1697, November, 1976.

Availability:

Available from:

Mathematics Research Center
University of Wisconsin - Madison
610 Walnut St.
Madison, Wisconsin 53706

Available for:

Any computer with ANSI standard FORTRAN

Languages:

ANSI Standard FORTRAN

Special instructions for description deck:

The description deck is in two logical parts: a heading and a body. The user must supply an intervening card, containing the number of dimensions desired as an integer beginning in Column 2.

Special cards to be added after *BEGIN: None

Special instructions to the linkage editor: None

Other comments:

User must provide work space and write subroutine to compute function of which gradient is to be computed. See documentation.

5. Conclusion:

This document is intended to be a guide for the use of the nonstandard data type packages described herein. Questions may be addressed to the author, or to the Mathematics Research Center. Information concerning additional supporting packages will be welcomed, and will be considered for inclusion in future revisions of this document.

No representation is made as to the accuracy, completeness, correctness, or suitability for any purpose of any of the packages described herein.

REFERENCES

1. F. D. Crary, The Augment precompiler I: User information, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report #1469, December, 1974 (revised April, 1976).

2. F. D. Crary, The AUGMENT precompiler II: Technical Documentation, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report #1470, October, 1975.

3. F. D. Crary and J. M. Yohe, The Augment Precompiler as a tool for the development of nonstandard arithmetic packages, The University of Wisconsin - Madison, Mathematics Research Center, Technical Summary Report #1892, October, 1978.

APPENDIX

RUNSTREAM FOR THE UNIVAC 1110
AT THE UNIVERSITY OF WISCONSIN - MADISON

1. General form of runstream:

The general form of the runstream is independent of the data type or types used. We give here the form of the runstream for the UNIVAC 1110 at the University of Wisconsin - Madison; in the next section we give any necessary modifications.

```
@ASG,A MRC*LIB.
@USE A.,MRC*LIB.
<obtain package file>
@USE P.,<package file>
@XQT A.AUGMENT
PRINT SUPPRESS (if listing of the description decks
                is not desired)
@ADD A.DESCRIPTION/FORTRAN-V
<descriptions>
*BEGIN
<any special cards>
*DISABLE WARNINGS (if AUGMENT warning messages
                               are not desired)
:FOR,<options> <filename,etc.>  (note ":" rather than
                                 "@" in Column 1)
<program>
:FOR,etc.
<subprogram>
etc.
*END
@ADD 20.
<any other processing, such as @PREP of files, compi-
 lation of other modules, etc.>
@MAP,I <absolute element>
 IN TPF$.
 <any special cards>
 LIB P.
@XQT <absolute element>
<data>
@FIN
```

If more than one nonstandard data type is to be used in a given program, all appropriate DESCRIPTIONs must be @ADDed, all required special cards must be included in the designated place, and all relevant LIB statements must be included in the @MAP sequence.

2. Details of specific nonstandard packages:

We now provide the information needed to "flesh out" the skeleton given above for each available nonstandard package.

A-1) DOUBLE PRECISION COMPLEX ARITHMETIC

<typename> := DBLCOMPLEX

<obtain package file> :=

```
@ASG,VTF MRCLIB.,U9V,6225
@REELID 6225/MRCLIB
@ASG,T DPC.
@GET,TA MRCLIB,DPC.
```

<package file> := DPC.

<descriptions> :=

```
@ADD P.DESCRIPTION/DBLCOMPLEX
```

Special cards to be added after *BEGIN: None

Special cards to be inserted after @MAP,I: None

A-2) MULTIPLE PRECISION ARITHMETIC (BRENT)

<typename> := MULTIPLE

<obtain package file> :=

```
@ASG,AX MRC*BRENT.
```

<package file> := MRC*BRENT.

<descriptions> :=

```
@ADD P.DESCRIPTION/MULTIPLE
```

Special cards to be added after *BEGIN: None

Special cards to be inserted after @MAP,I: None

A-3) MULTIPLE PRECISION ARITHMETIC (WYATT, LOZIER, AND ORSER)

NOT AVAILABLE

A-4) MULTIPLE PRECISION ARITHMETIC

<typename> := MULTIPLE

<obtain package file> := no action required

<package file> := MRC*LIB.

<descriptions> :=

@ADD P.DESCRIPTION/MULTIPLE

Special cards to be added after *BEGIN: None

Special cards to be inserted after @MAP,I: None

B-1) INTERVAL ARITHMETIC (SINGLE PRECISION)

<typename> := INTERVAL

<obtain package file> :=

```
@ASG,VTF MRCLIB.,U9V,6225
@REELID 6225/MRCLIB
@ASG,T MRC*INTLIB.
@GET,TA MRCLIB,MRC*INTLIB.
```

<package file> := MRC*INTLIB.

<descriptions> :=

```
@ADD P.DESCRIPTION/INTERVAL
```

Special cards to be added after *BEGIN:

```
*CONVERT EXTENDED - DOUBLE PRECISION
```

Special cards to be inserted after @MAP,I:

```
IN P.INTERVAL
(Do NOT use "LIB P." card)
```

B-2) INTERVAL ARITHMETIC (MULTIPLE PRECISION)

<typename> := INTERVAL

<obtain package file> :=

```
@ASG,VTF MRCLIB.,U9V,6225
@REELID 6225/MRCLIB
@ASG,T MRC*INTLIB.
@GET,TA MRCLIB,MRC*INTLIB.
```

<package file> := MRC*INTLIB.

<descriptions> :=

```
@ADD P.DESCRIPTION/INTERVAL-MP
```

Special cards to be added after *BEGIN:

```
*CONVERT EXTENDED - MULTIPLE
```

Special cards to be inserted after @MAP,I:

```
IN P.INTERVAL-MP
(Do NOT use "LIB P." card)
```

B-3) TRIPLEX ARITHMETIC (SINGLE PRECISION)

<typename> := TRIPLEX

<obtain package file> :=

```
@ASG,VTF MRCLIB.,U9V,6225
@REELID 6225/MRCLIB
@ASG,T MRC*INTLIB.
@GET,TA MRCLIB,MRC*INTLIB.
```

<package file> := MRC*INTLIB.

<descriptions> :=

```
@ADD P.DESCRIPTION/TRIPLEX
```

Special cards to be added after *BEGIN:

```
*CONVERT EXTENDED - DOUBLE PRECISION
```

Special cards to be inserted after @MAP,I:

```
IN P.TRIPLEX
(Do NOT use "LIB P." card)
```

B-4) TRIPLEX ARITHMETIC (MULTIPLE PRECISION)

<typename> := TRIPLEX

<obtain package file> :=

```
@ASG,VTF MRCLIB.,U9V,6225
@REELID 6225/MRCLIB
@ASG,T MRC*INTLIB.
@GET,TA MRCLIB,MRC*INTLIB.
```

<package file> := MRC*INTLIB.

<descriptions> :=

```
@ADD P.DESCRIPTION/TRIPLEX-MP
```

Special cards to be added after *BEGIN:

```
*CONVERT EXTENDED - MULTIPLE
```

Special cards to be inserted after @MAP,I:

```
IN P.TRIPLEX-MP
(Do NOT use "LIB P." card)
```

C-1) ANALYTIC DIFFERENTIATION - TAYLOR SERIES EXPANSION

<typename> := TAYLOR

<obtain package file> :=

```
@ASG,VTF MRCLIB.,U9V,6225
@REELID 6225/MRCLIB
@ASG,T GK*DIFF.
@GET,TA MRCLIB,GK*DIFF.
```

<package file> := GK*DIFF.

<descriptions> :=

```
@ADD P.DESC-TYL/HEAD
<# of derivatives (beginning in Col. 2)>
@ADD P.DESC-TYL/BODY
```

Special cards to be added after *BEGIN: None

Special cards to be inserted after @MAP,I: None

C-2) ANALYTIC DIFFERENTIATION - GRADIENT COMPUTATION

<typename> := GRADIENT

<obtain package file> :=

```
@ASG,VTF MRCLIB.,U9V,6225
@REELID 6225/MRCLIB
@ASG,T GK*DIFF.
@GET,TA MRCLIB,GK*DIFF.
```

<package file> := GK*DIFF.

<descriptions> :=

```
@ADD P.DESC-GRD/HEAD
<# of dimensions (beginning in Col. 2)>
@ADD P.DESC-GRD/BODY
```

Special cards to be added after *BEGIN: None

Special cards to be inserted after @MAP,I: None

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 1907	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) NONSTANDARD ARITHMETIC PACKAGES FOR FORTRAN		5. TYPE OF REPORT & PERIOD COVERED Summary Report - no specific reporting period 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. M. Yohe		8. CONTRACT OR GRANT NUMBER(s) DAAG29-75-C-0024
9. PERFORMING ORGANIZATION NAME AND ADDRESS Mathematics Research Center, University of Wisconsin 610 Walnut Street Madison, Wisconsin 53706		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS #8 - Computer Science
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Office P.O. Box 12211 Research Triangle Park, North Carolina 27709		12. REPORT DATE January 1979 13. NUMBER OF PAGES 23
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

FORTRAN Precompiler
Nonstandard Data Types
Software Packages
Multiple Precision Arithmetic
Interval Arithmetic
Triplex Arithmetic
Analytic Differentiation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

We describe various available supporting packages for the AUGMENT precompiler for FORTRAN, and provide instructions for their use in conjunction with AUGMENT.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)